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SOME METHODS OF DETERMINING THE POSITIVE
OR NEGATIVE CHARACTER OF MINERAL PLATES
IN CONVERGING POLARIZED LIGHT WITH
THE PETROGRAPHICAL MICROSCOPE.

By DR. M. E. WADSWORTH, Houghton, Mich.

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**SOME METHODS OF DETERMINING THE POSITIVE
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For the elementary work in petrography in the Michigan College of Mines the laboratory is furnished with twenty-nine Bausch and Lomb petrographical microscopes specially made for the college, besides numerous other microscopes and petrographical apparatus, making it one of the best equipped laboratories known.

In giving instruction in the use of the petrographical microscope as a polariscope, I have found a few directions of value to my students,—directions which I do not remember of having ever seen published. Thinking that they might be of some value to some of our readers who are interested in optical mineralogy, these directions are published here. Since by varying the powers, the petrographical microscope can be used with mineral plates of any standard thickness, the directions here given can be used with the ordinary polariscope plates as well as those thinner ones prepared expressly for use with the microscope.

I. UNIAXIAL MINERALS.

When the mineral plate shows the common uniaxial cross in converging light its positive or negative character can be ascertained by means of the gypsum plate or quartz wedge, as well as by the ordinary mica plate.

(1) *Use of the Gypsum Plate.*

Examine the mineral plate, which, in converging polarized light, between crossed nicols, shows a dark cross or part of a cross with or without colored rings or arcs. Insert the gypsum plate in the slot in the body of the microscope above the objective. The cross is then resolved into colored hyperbolas. The central portion is red terminated on the ends with yellow and bordered on the side by blue. If the blue that borders the red lies on a line parallel to the axis of least elasticity, the mineral is POSITIVE, but if it lies on opposite sides of this line the mineral is NEGATIVE. The gypsum plate is often more satisfactory in its use than the mica plate for these determinations.

(2) *Use of the Quartz Wedge.*

Insert the quartz wedge thin end forward. When the wedge is gradually pushed in the cross resolves itself into colored arcs that cross the field of view from two opposite sides of the field and pass out of sight on the other two sides. These arcs follow each other in succession as the wedge is pushed in. If these colored arcs advance towards the center of a line parallel to the axis of least elasticity the mineral is POSITIVE. But if they march toward the center from opposite sides of that line the mineral is NEGATIVE.

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The use of the quartz wedge is less liable to error than either of the preceding; and besides it can be used in many cases where the others give no results.

(a) If the uniaxial plate is cut so that it shows arcs of rings, its positive or negative character can be determined by placing the arcs so a line perpendicular to them shall make an angle of 45° with the cross hairs. By use of the quartz wedge, colored arcs or rings can often be brought into the field, when otherwise none are seen. Push in the quartz wedge with its axis of least elasticity tangent to the arcs. If the rings then move outwards with their convex side forwards, and, in time, a black or partially black arc appears, the mineral is **POSITIVE**, but if the arcs move with their concave sides forwards the mineral is **NEGATIVE**.

As a check against any error, turn the wedge over and push it in, so its axis of least elasticity will be perpendicular to the arcs. If then the arcs move with the concave side forward, the mineral is **POSITIVE**, but if they move with the convex side forwards, and a black or partially black ring or rings show, the mineral is **NEGATIVE**.

(b) A uniaxial plate cut parallel to the vertical axis can have its positive or negative character shown in converging polarized light as follows: Place the plate at an angle of 45° with the cross hairs so as to show the colored arcs or imperfect hyperbolas. Push in the quartz first with its axis of least elasticity perpendicular to the vertical or optic axis of the plate. If on pushing along the quartz wedge a dark hyperbola is seen to pass over the field the mineral is **POSITIVE**. Again, push in the quartz wedge with its axis of least elasticity parallel to the vertical axis of the plate. If then a dark hyperbola is seen to traverse the field, the mineral is **NEGATIVE**.

II. BIAXIAL MINERALS.

In order to render intelligible the directions later given, there is here stated the method published in the text books for determining the positive or negative character of a biaxial mineral plate.

If a line of extinction of a biaxial plate properly cut is placed parallel to one of the cross hairs, it shows a cross with unequal arms; but if the line of extinction makes an angle of

45° with that cross hair, it shows two dark hyperbolas, whose vertices or eyes mark the position of the optic axes. Accompanying the cross and hyperbolas are colored lemniscate figures. Oftentimes the hyperbolas are wanting and only the colored lemniscates can be seen; but by the insertion of the quartz wedge the hyperbolas can frequently be brought into the field.

(a) The positive or negative character of this biaxial plate can then be determined by placing the plate on the stage in such a position that a line joining the hyperbola eyes or bisecting the lemniscates through their longest direction shall form an angle of 45° with the cross hairs. Push in the quartz wedge with its axis of least elasticity parallel to the line joining the hyperbola eyes. If the hyperbola eyes open and move toward the center of the lemniscate figure the mineral is **POSITIVE**.

Push in the quartz wedge with its axis of least elasticity perpendicular to the line joining the hyperbola eyes. If these eyes open and move toward the center of the lemniscate figure, the mineral is **NEGATIVE**.

Of course, if in either case the eyes contract and move outwards, this is proof, when the axis of least elasticity of the quartz wedge is perpendicular to the line joining the hyperbola, that the mineral plate is **POSITIVE**; but if they move outward when the axis of elasticity is parallel to the chosen line, the mineral is **NEGATIVE**.

This method is less satisfactory in practice than the one where the eyes open and move inwards.

(b) The above method given in our text books can be supplemented by one that can be employed in numerous cases when both of the hyperbola eyes cannot be seen, but only one of them or only the lemniscate arcs. In either of these cases the positive or negative character of the mineral plate can be ascertained; if one can determine the position of the line joining the hyperbola eyes or optic axes, by the form of the interference figures, by the position of the larger arm of the cross or by any other means. When this direction is observed, place the arcs so that the direction of the line joining the hyperbola vertices shall be perpendicular to, or bisect, them; also have this line make an angle of 45° with the cross hairs as

before. Push in the wedge with its axis of least elasticity perpendicular to the arcs or parallel to the line joining the hyperbola eyes. If the lemniscate arcs move in towards the center of the field with their convex side forwards the mineral is POSITIVE.

Push in the wedge with its axis of least elasticity tangent to the arcs or perpendicular to the line joining the vertices. If the arcs then move in with their convex side forwards the mineral is NEGATIVE. If the arcs move outwards with their concave side forwards the mineral in the first position of the wedge is NEGATIVE, and in the second position POSITIVE

(c) If the distance between the hyperbola eyes is not so great but that they lie within the field of view, the mica and gypsum plates can both be employed to determine the positive and negative characters when the lemniscate figure is placed as before, with the line joining the hyperbola eyes forming an angle of 45° with the cross hairs of the eye piece. Insert either the mica plate with its axis of least elasticity parallel to the chosen line, or else insert the gypsum plate with its axis of least elasticity perpendicular to the chosen line. With either plate in this position the arcs on one side of the hyperbola eyes will enlarge and those on the other side contract. If the arcs that lie on the inside of the eyes, or nearest the center of the figure, enlarge, and those on the outside contract, the mineral is POSITIVE. On the other hand, if the arcs nearest the center contract and the outside arcs expand the mineral is NEGATIVE. This method can be used with plates that have too great an axial divergence to admit of their determination when the unsymmetrical cross is placed with its arms parallel to the cross hairs.

III. CHROMATIC SCALE.

Many students find it difficult to follow the color scales given in most text books of petrography owing to the numerous subdivisions of the scales. This difficulty can be obviated in part by each student making for himself a color scale suited to his eyes and experience. It is found that many students mistake their ignorance of the names of color tints for color blindness. The scale is made by placing the quartz wedge on the stage of the microscope with the nicols crossed. Then

push the wedge with its thin end forwards through the field of view of the microscope. Note the colors as they rise in the scale, as the successively thicker portions of the wedge pass in view. The scale thus noted will be suited to the wedge employed and to the student using it at that stage of his experience. The operation can be repeated with the nicols parallel if desired.

IV. SECTION AND PLATE.

I have found it convenient in practice to distinguish the terms "section" and "plate" in the microscopic study of minerals and rocks as follows:

The term "section" is employed to indicate the entire mass of the rock or mineral that is carried by the glass slide used on the stage of the microscope. The term "plate" is introduced to designate a particular section or slice of mineral or other substance that forms a part of the rock or general mass carried by the glass slide. A "section" is composed of "plates." A rock "section" is usually made up of many mineral "plates" either held together by intercrystallization or by some cementing material which material in its turn lies in an irregular "plate" or in "plates."

"Plate" is never the equivalent of "section," unless a single "plate" of one mineral forms the entire "section."



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